LOCATING MONITORING WELLS AND GIS MODELING TO EVALUATE SOURCE CONTROL STRATEGIES TO ADDRESS ACID MINE DRAINAGE AT BELT MONTANA

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Abstract. The Abandoned Mines Section of the Montana Department of Environmental Quality, Mine Waste Cleanup Bureau and the Montana Bureau of Mines and Geology drilled 12 new monitoring wells at 9 new sites in the last year. This effort was designed to evaluate strategies for controlling the source water of acid mine drainage (AMD) leaving the Anaconda Coal Mine outside of Belt, Montana and entering Belt Creek. Initial three dimensional (3D) geographic information system (GIS) modeling of the mines, geology, and ground-water levels predicted varying water levels in underground workings that ranged from completely inundated through partially flooded to dry. Water levels in new wells generally corroborated these results, and provided data that allowed for much more detailed analysis. The revised, detailed 3D models will be useful to identify areas of recharge and help formulate remediation strategies. Potential strategies include source control through changes in cropping practices, installation of bulkheads in the mine, and drilling of horizontal wells.

Additional Key Words: Anaconda Coal Mine, geographic information systems, ground water.

Introduction

Coal mining in Montana began in earnest with the coming of railroads in the 1880s. Railroads, as well as the timber, cattle and mineral industry, needed Montana coal. Coal also made possible the smelting of the ores from the rich lodes being discovered in the state. Montana coal provided the burgeoning homesteaders with home heating and provided power to developing towns and cities. From the earliest coal produced for steamboat fuel in the 1870's until the post World War II collapse of the underground coal industry, Montana underground coal mines produced an estimated 250 million tons of coal.

Reclamation work has been completed on many of these coal mines, with the exception of those producing acid mine drainage, a complex problem for which Montana has no economically affordable solution at this time. Acid mine drainage (AMD) is

ubiquitous to the Great Falls-Lewistown Coal Field (Figure 1). Stretching east from the city of Great Falls, 100 miles to Lewistown Montana this coalfield has 400 abandoned coalmines; many are generating AMD. Because of the high sulphur and associated pyrite content of the coal, the AMD released from these mines is particularly devastating to Montana's streams and property. The coal mined in this field is uncharacteristic of the coal mined elsewhere in the state; being a sub bituminous B to high volatile C bituminous coal containing an average sulphur content of 4%, with sulfur content in places as high as 11%.

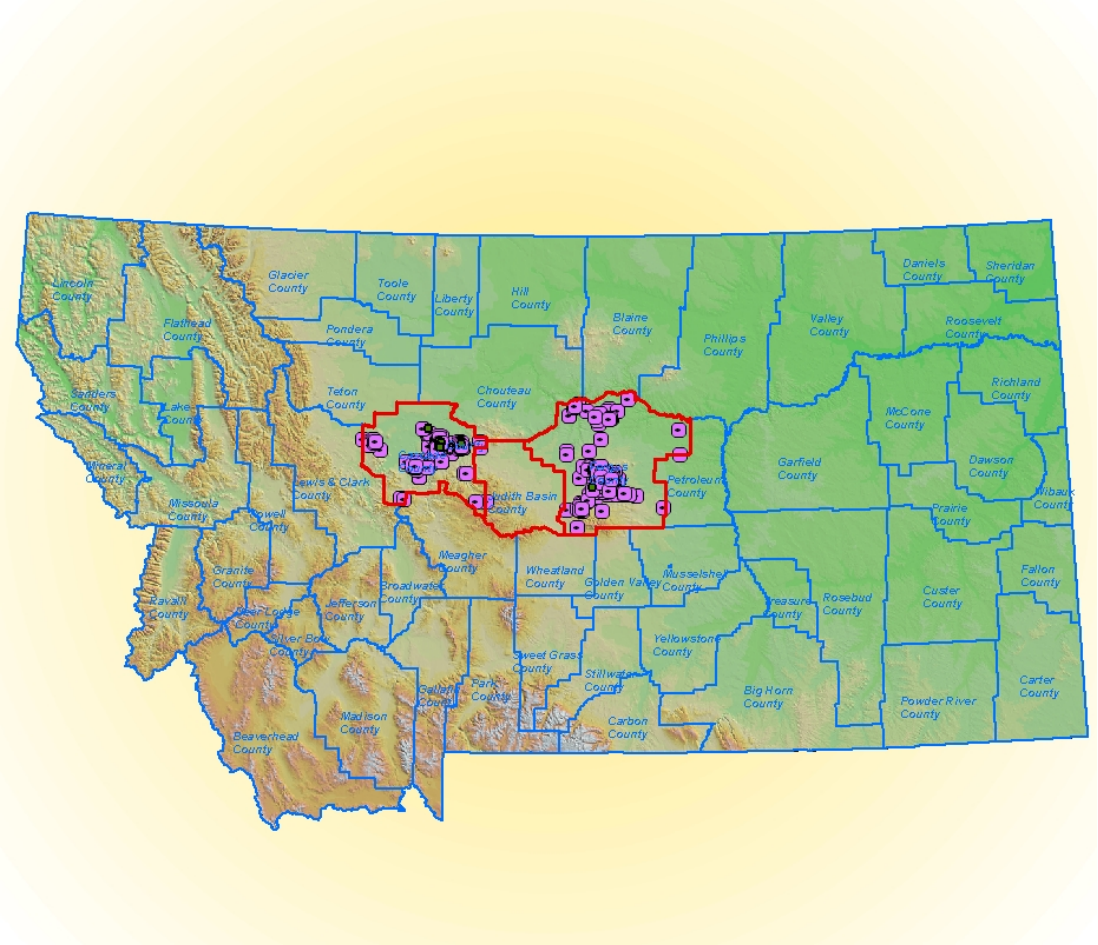

Figure 1. Abandoned coal mines in the Great Falls – Lewistown Coal Field, Montana.

The Belt coal area is 20 miles east-southeast of Great Falls. The town of Belt is the site of several abandoned underground coalmines, including the Anaconda Mine whose workings extend approximately 5 square miles back into the hillside southwest of the town. The Anaconda Mine operated from 1877 to 1922 (GCM Services Inc.,1983). The Anaconda Mine was known for the iron-pyrite nodules that were found in the coal, which were the source of this coal's sulfur. These nodules were so abundant that they were separated from the coal and shipped to a copper smelter in Great Falls and used as flux and additional fuel in the blast furnace charge, Fisher (1909). Silverman and Harris (1967) stated that the mine employed more than 1,000 men and produced an average of

300,000 tons of coal per year during its peak period of production, approximately 25 years.

Monitoring Wells and 3D Modeling

The Abandoned Mines Section of the Montana Department of Environmental Quality, Mine Waste Cleanup Bureau and Montana Bureau of Mines and Geology drilled twelve new monitoring wells at nine new sites in the last year. This effort was designed to evaluate strategies for controlling the source water of acid mine drainage (AMD) leaving the Anaconda Coal Mine outside of Belt, Montana and entering Belt Creek.

The current monitoring network for surface water and groundwater includes five surface water-monitoring sites, each equipped with flumes, and pressure transducers to record hourly stage height to calculate flow rates. Monitoring of the physical parameters (i.e. pH, temperature, and specific conductance) of the water discharging from the Anaconda Mine will be continued to establish baseline conditions to evaluate remediation success.

A series of monitoring wells have been installed (Figure 2). Six of the sites have two or more wells to monitor groundwater levels and quality of water found in the various aquifers and within the mine workings. This monitoring network includes water-level transducers to record changes in water level responses to recharge events, and seasonal variations. Data sondes are also used to monitor physical parameters similar to those used at the surface water sites. This is important in the transition zone between flooded and partially flooded portions of the mine.

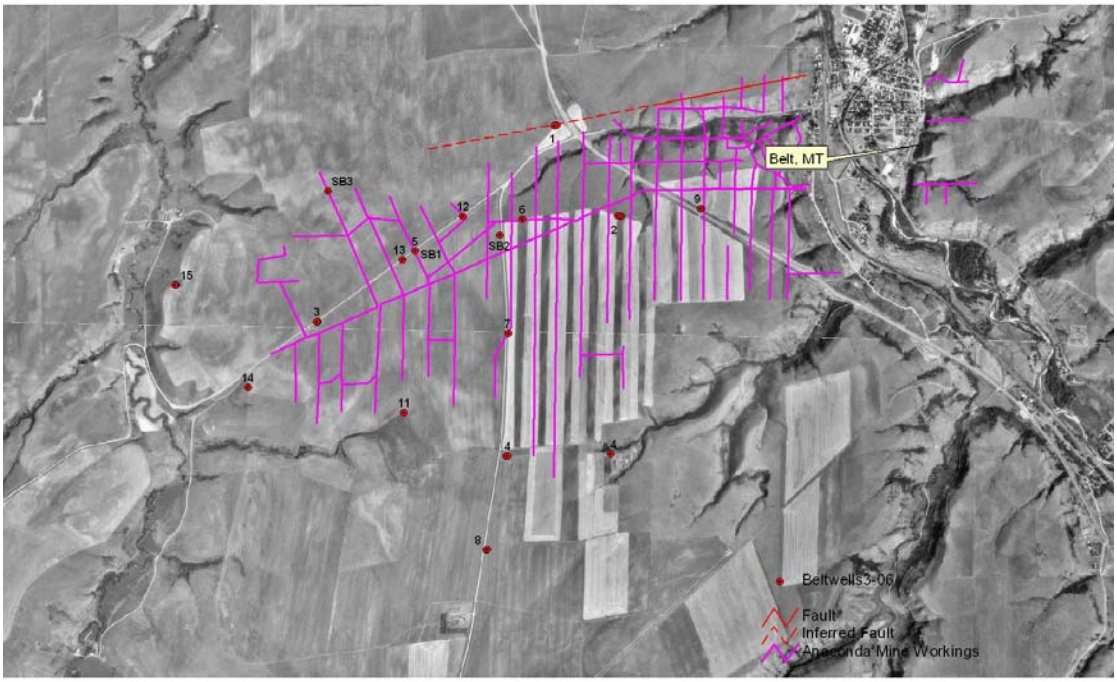

Figure 2: Monitoring wells of the Anaconda Coal Mine, Belt, MT.

Initial three dimensional (3D) geographic information system (GIS) modeling of the mines, geology, and groundwater levels predicted varying water levels in underground workings, from completely inundated through partially flooded to dry. Maps and figures were produced showing cross sections of the mine workings, geologic units, water levels and land use practices.

Water levels in new wells generally corroborated levels that were predicted from the 3D GIS model (Figure 3). Additionally, these wells provided data that allowed for much more detailed modeling and analysis. The revised, detailed 3D models will be useful to identify areas of recharge and help formulate remediation strategies. Potential strategies include source control through changes in cropping practices, installation of bulkheads in the mine, and drilling of horizontal wells.

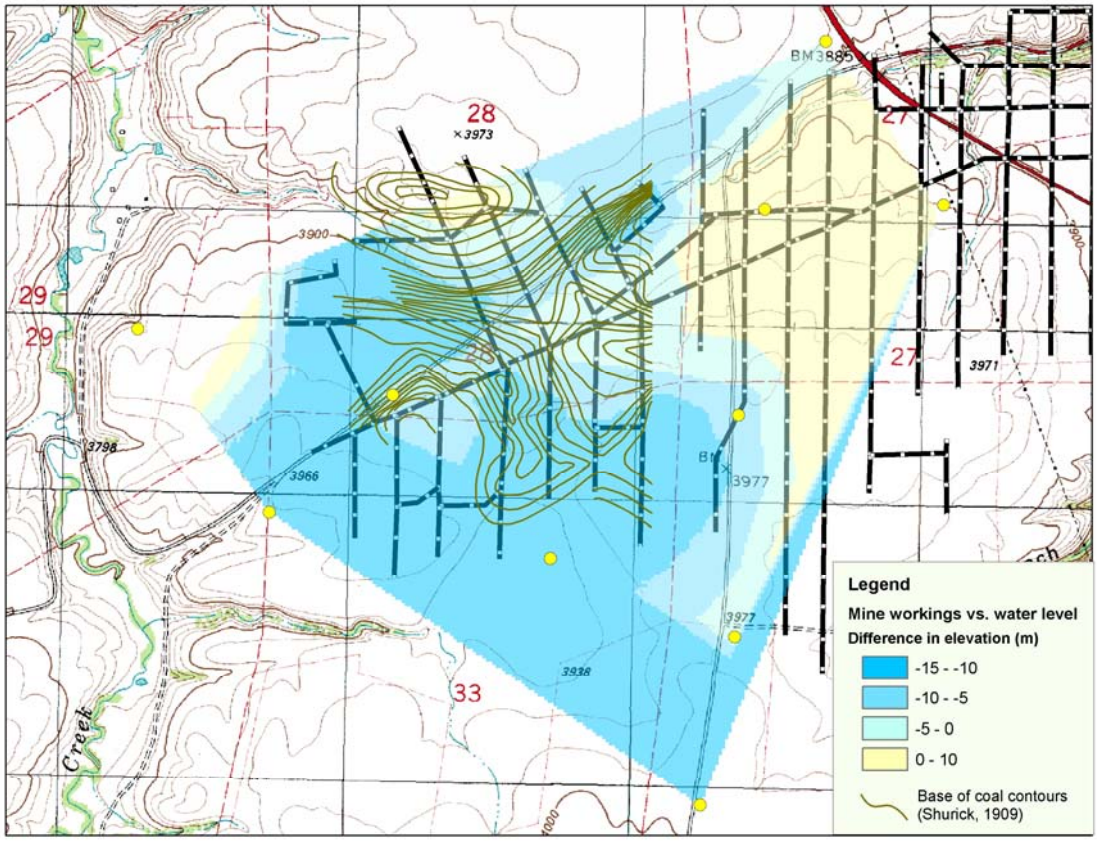

Figure 3. Mine workings and water levels in the Belt Coal Mine, Montana.

Literature Cited

Fisher, C.A., 1909, Geology of the Great Falls Coal Field, Montana, U.S. Geological Survey Bulletin 356.

GCM Services, Inc., 1983, Cultural Resource Inventory and Evaluation; A.C.M.-Boston and Montana - Brodie-French Coulee Mines, Belt, Montana, prepared for Montana Department of State Lands, Helena, MT.

Silverman, A.J., and Harris, W.L., 1967, Stratigraphy and Economic Geology of the Great Falls-Lewistown Coal Field, Central Montana, Montana Bureau of Mines and Geology Bulletin 56.